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Meyer

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[54] OPPOSED ARM WEB ACCUMULATOR

[75] Inventor: **Thomas C. Meyer**, Elkhart Lake, Wis.

[73] Assignee: **Curt G. Joa, Inc.**, Boynton Beach, Fla.

[21] Appl. No.: **833,811**

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Related U.S. Application Data

[62] Division of Ser. No. 690,493, Apr. 24, 1991, abandoned.

[51] **Int. Cl.**[5] **B65H 20/24**; B65H 19/18; B65H 59/12

[52] **U.S. Cl.** **226/119**; 242/58.1; 242/154

[58] **Field of Search** 226/118, 119; 242/58.1, 242/75.51, 154

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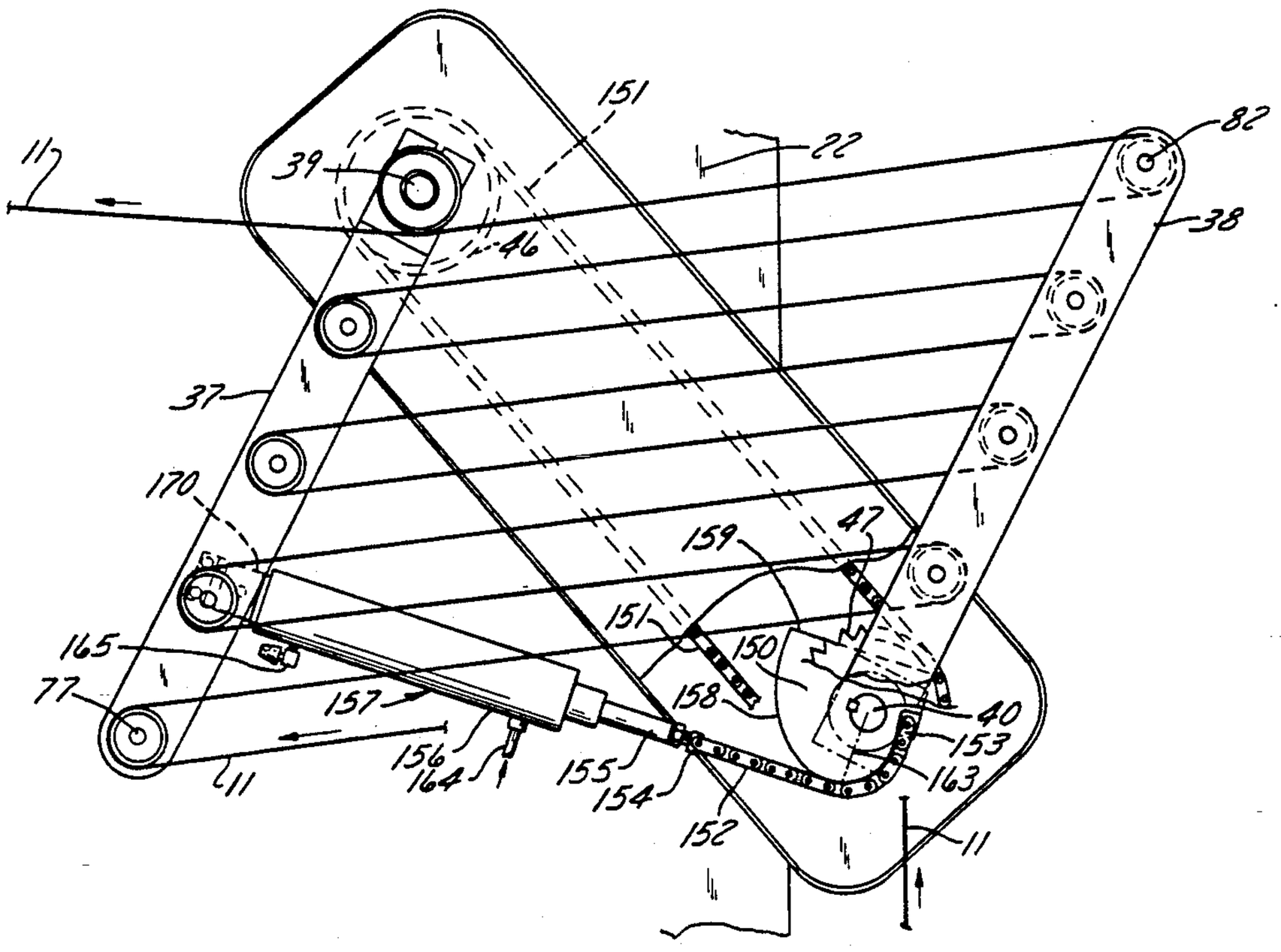
Primary Examiner—Daniel P. Stodola
Assistant Examiner—Michael R. Mansen
Attorney, Agent, or Firm—Fuller, Ryan, Hohenfeldt & Kees

[57] **ABSTRACT**

In one embodiment of a web accumulator, at least one pneumatic cylinder actuator has a chain loop connected to opposite ends of its piston rod. Translation of the chain in response to pressurizing the cylinder causes the chain to drive two spaced apart axle shafts in the same rotational direction. An arm is fastened to each axle shaft and there is a row of rollers on each arm and a roller on each axle shaft. Web is threaded in loops back and forth between rollers on the respective arms. When the web infeed rate to the accumulator and the outfeed or rate at which the web is drawn out by a web consuming device are equal, the regulated air pressure to the actuator drives the arms apart to thereby accumulate a long length of web. When web infeed is interrupted while outfeed or draw persists, the arms are pulled toward each other and they pay out the stored length of web. In one embodiment, web tension may vary with the angles of the arms on each side of an imaginary center line to which the axes of the axle shafts are perpendicular. Compensation for such variance may be made by varying the air pressure is accordance with such angle. In the other embodiment, the chain drives the axle shafts through a lever whose radius varies along its profile, providing constant tension throughout the range of angular motion.

3 Claims, 7 Drawing Sheets



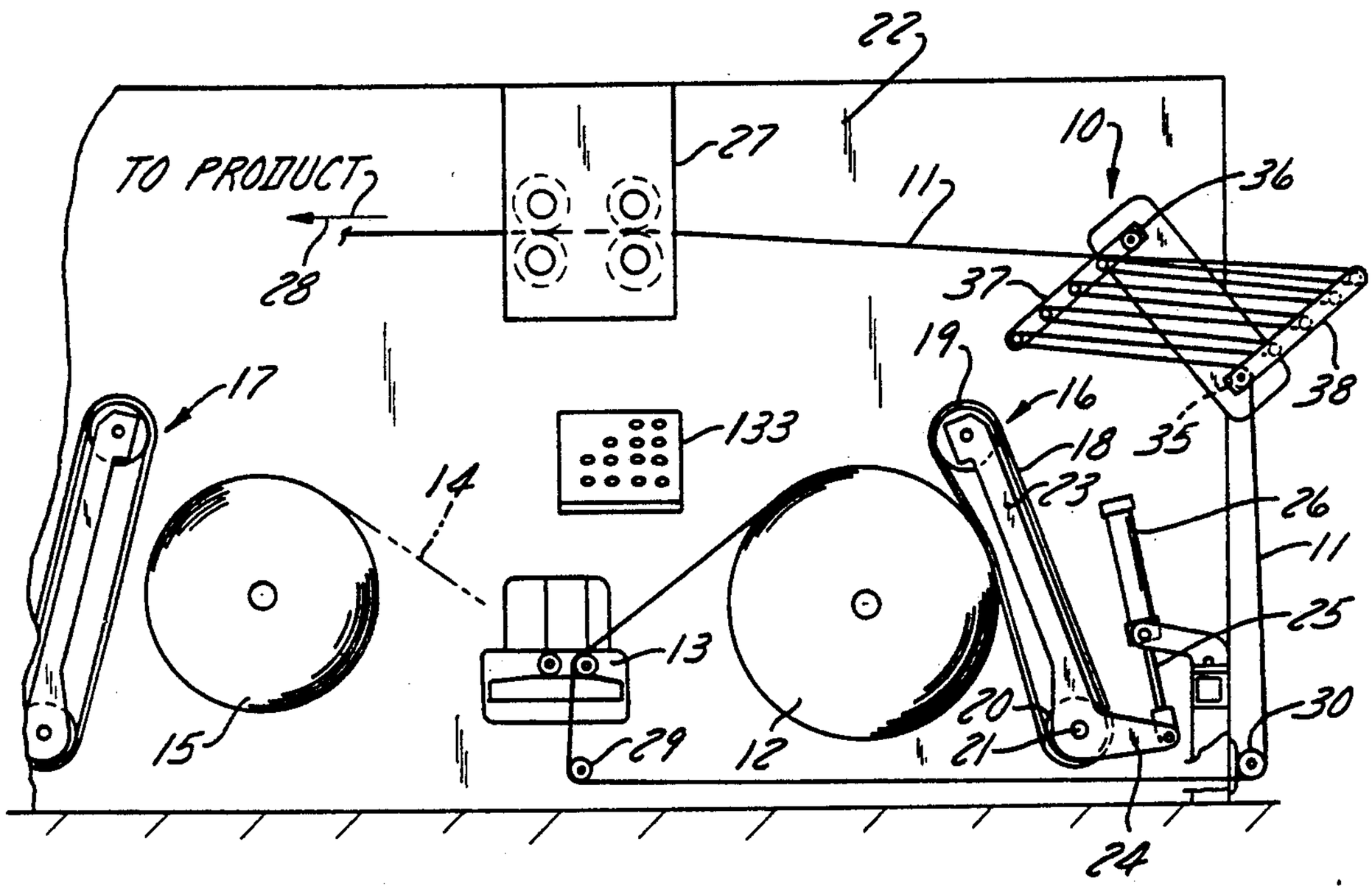

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FIG. 1

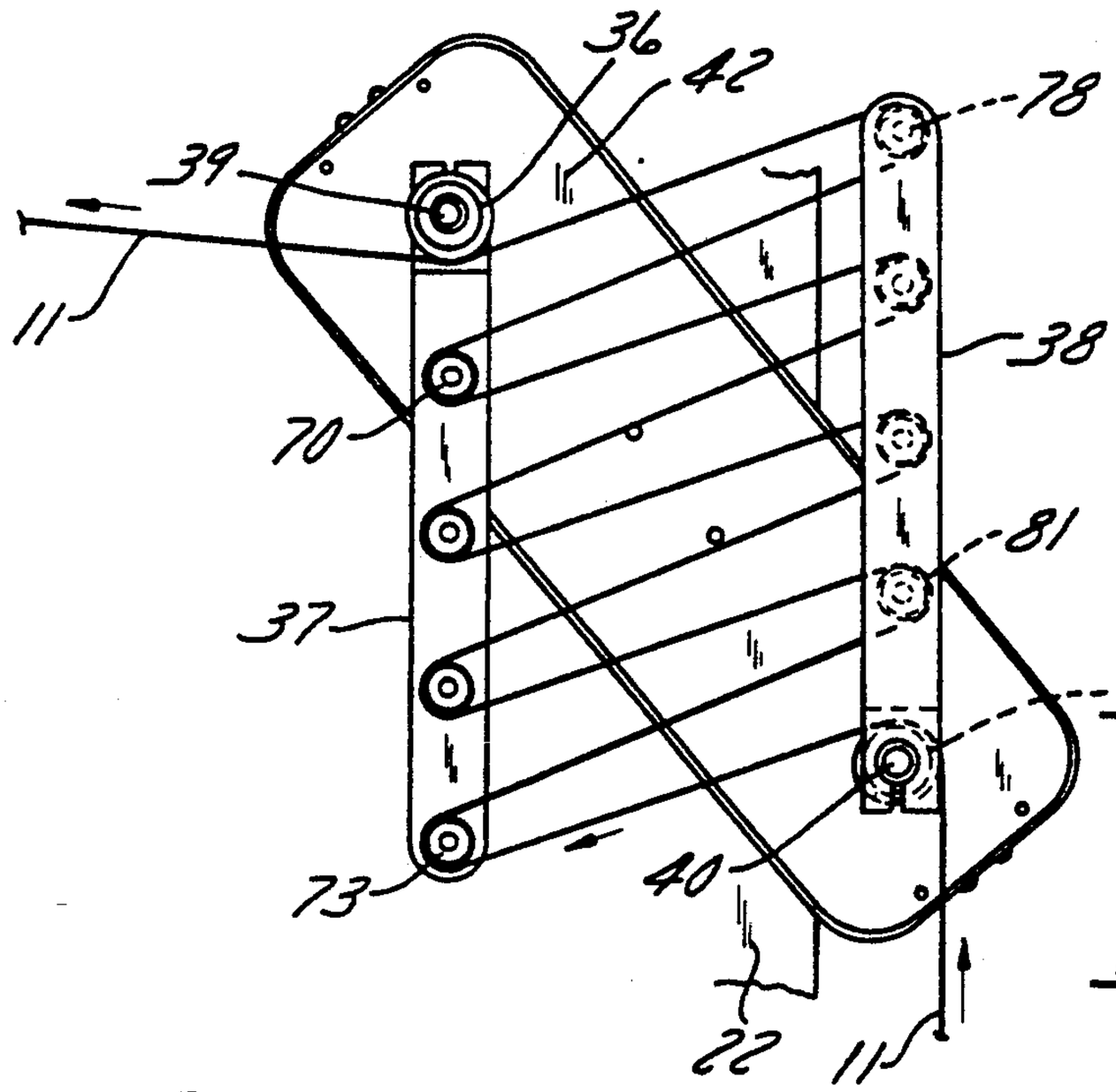
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FIG. 3

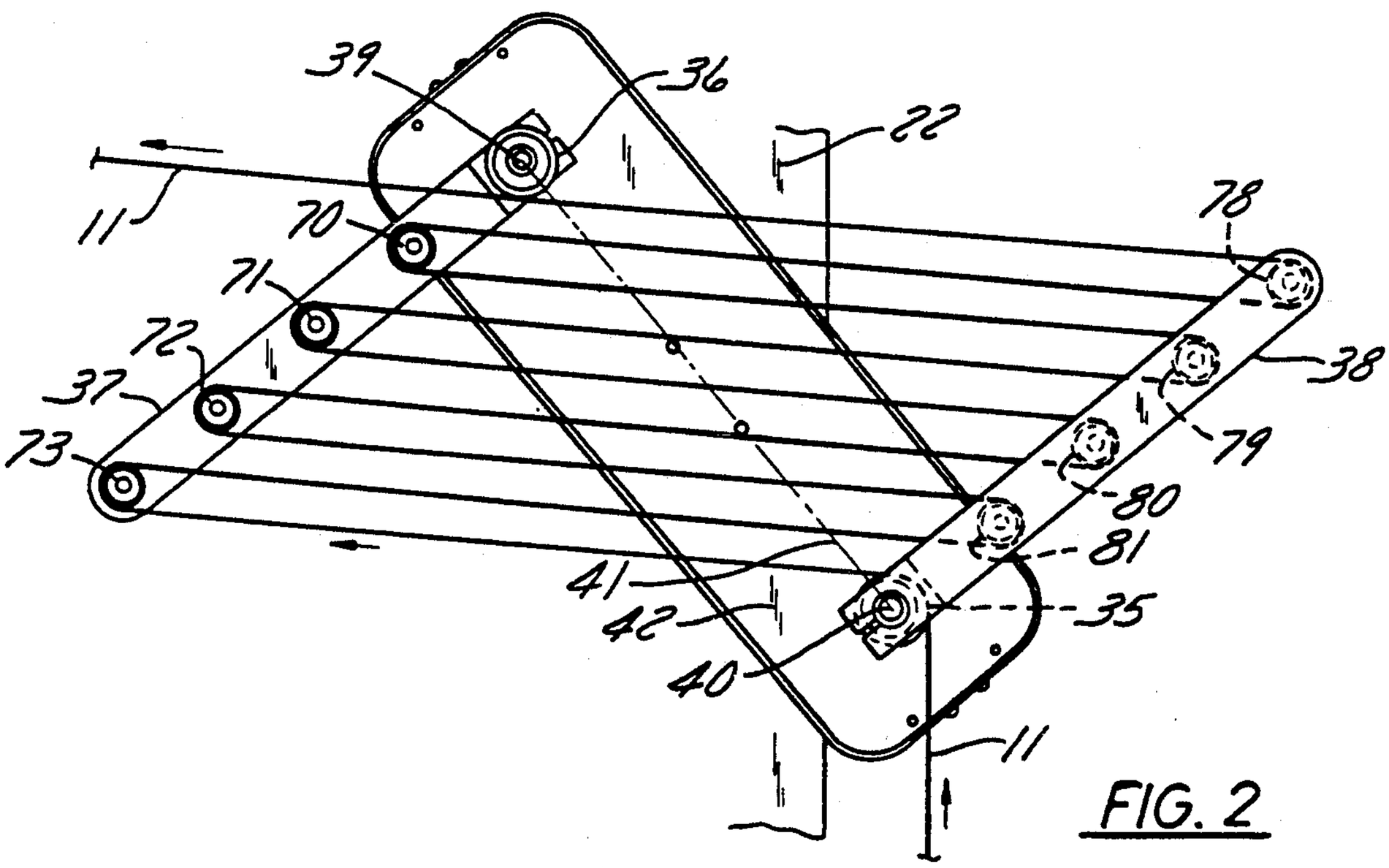
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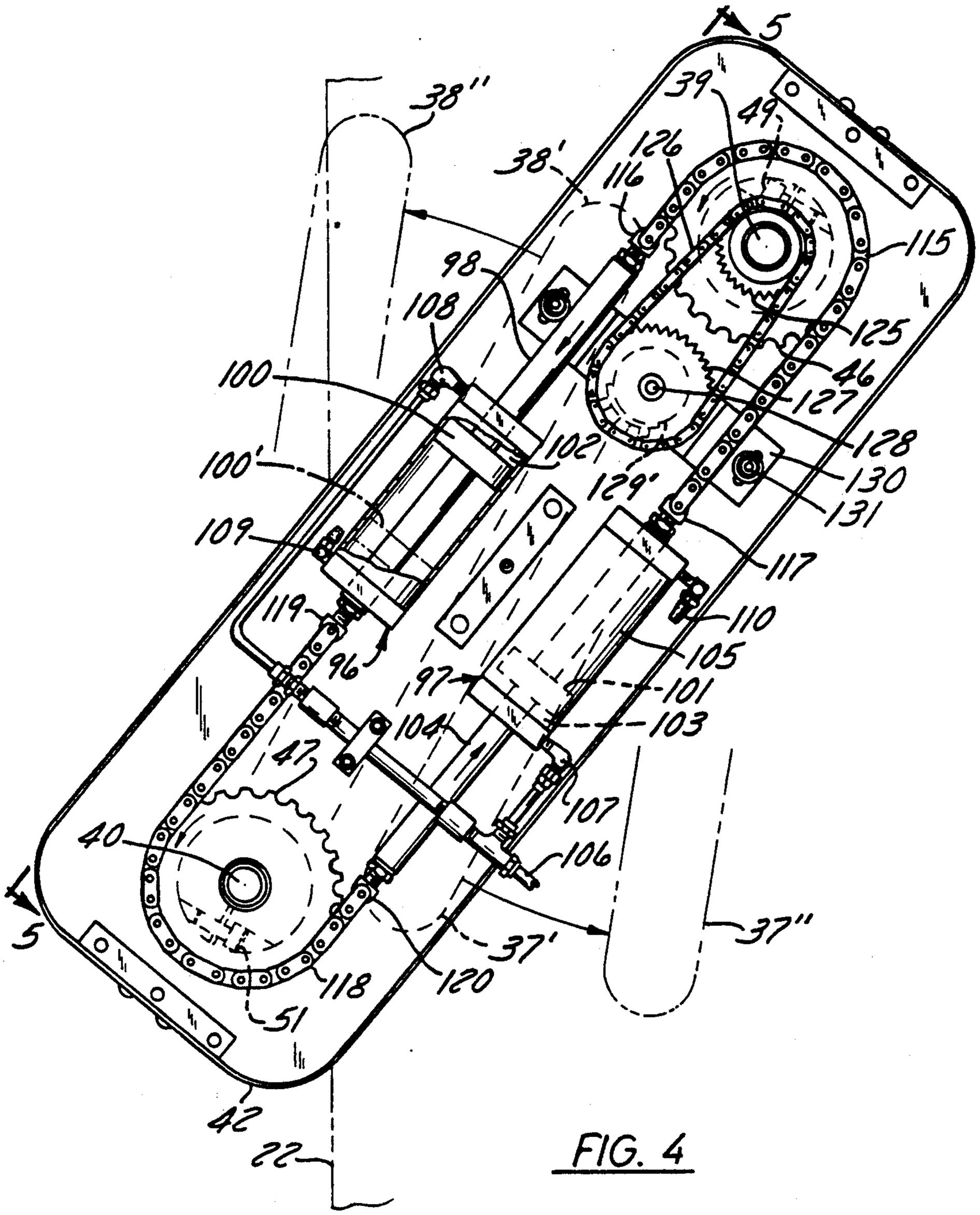
FIG. 2


5
38''
38'
39
49
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116
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98
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109
117
119
110
105
96
97
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104
103
47
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37'
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118
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42
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FIG. 4

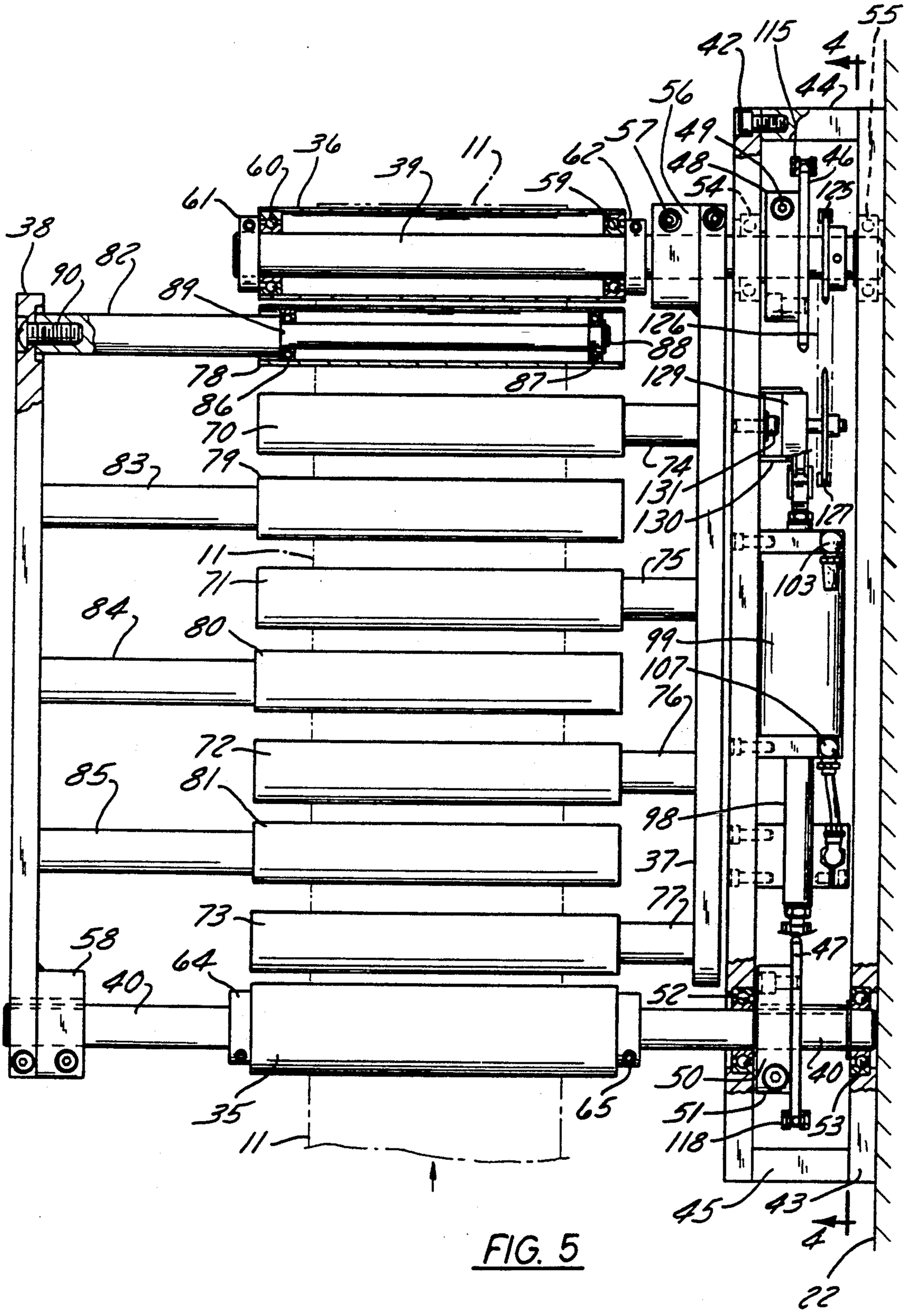
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FIG. 5

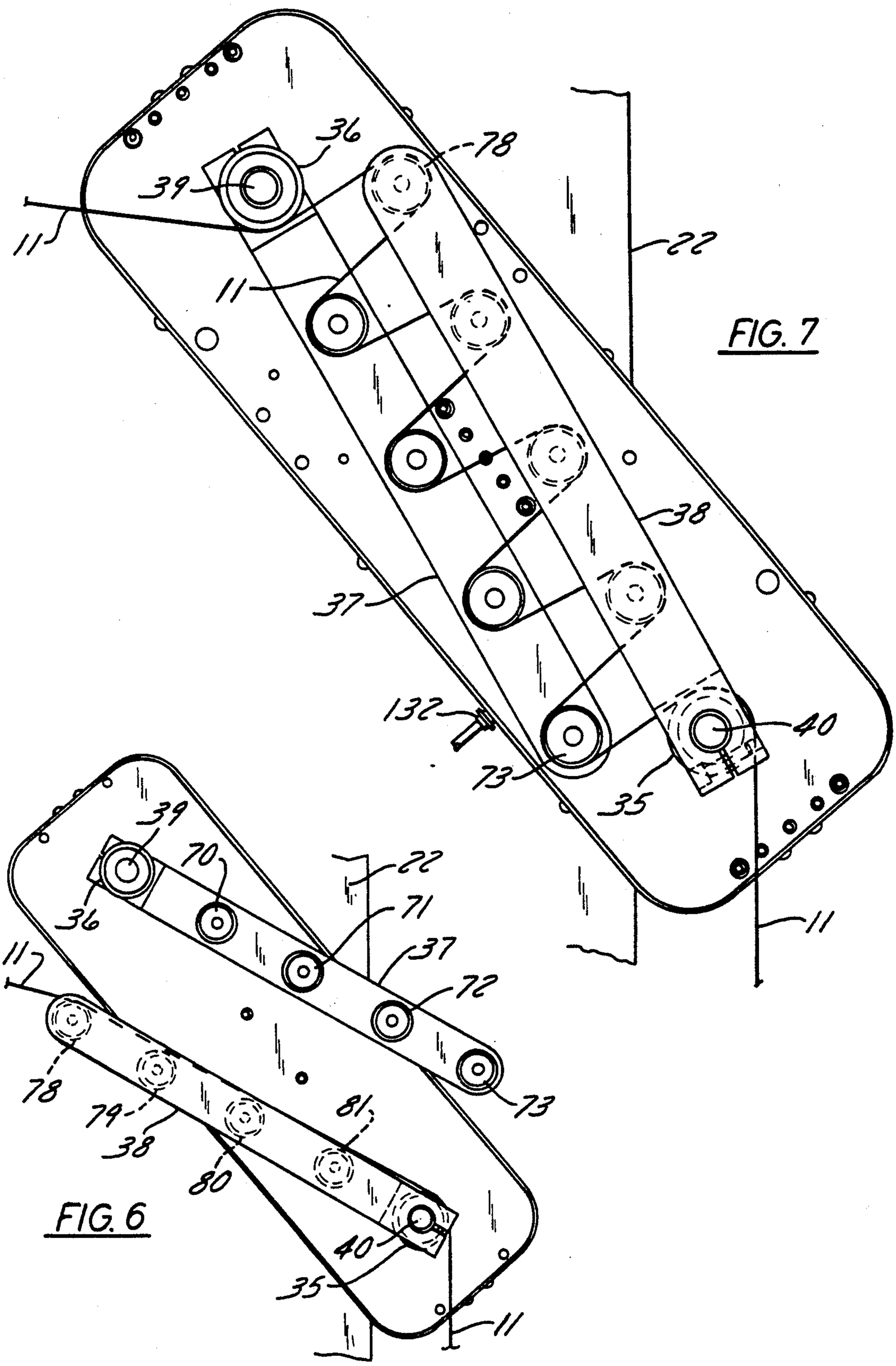
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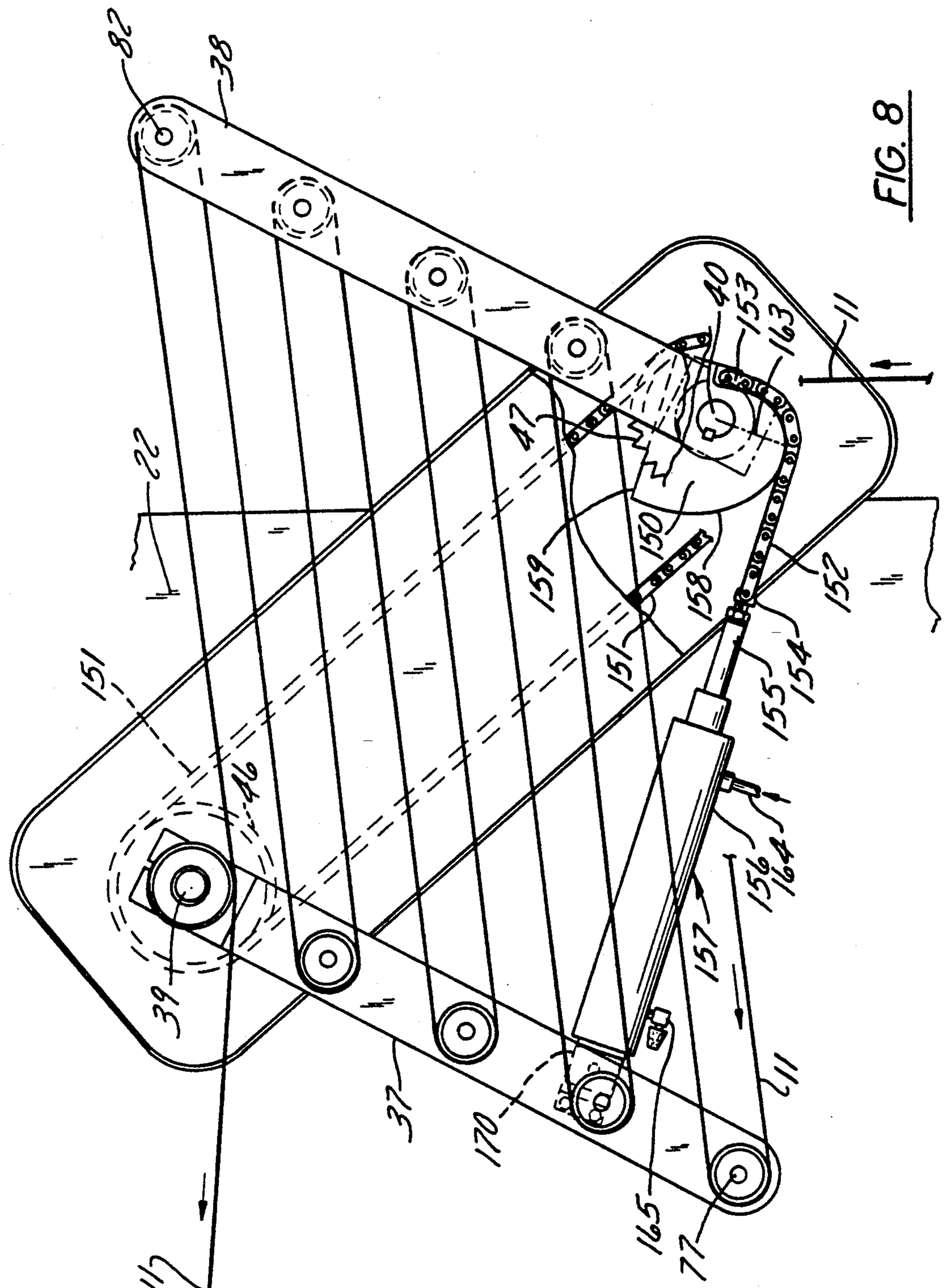
FIG. 7

FIG. 6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163
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112

FIG. 8

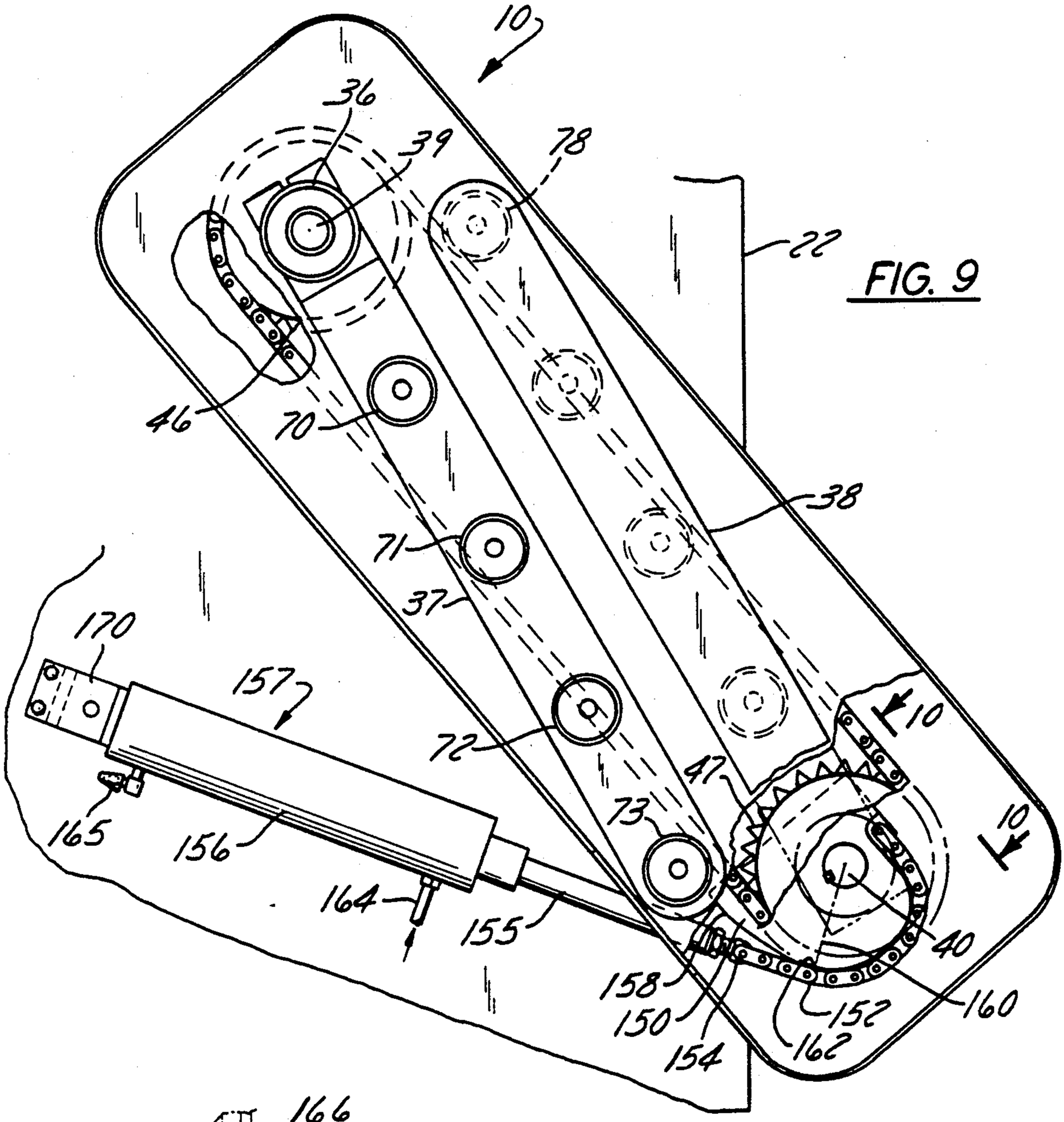
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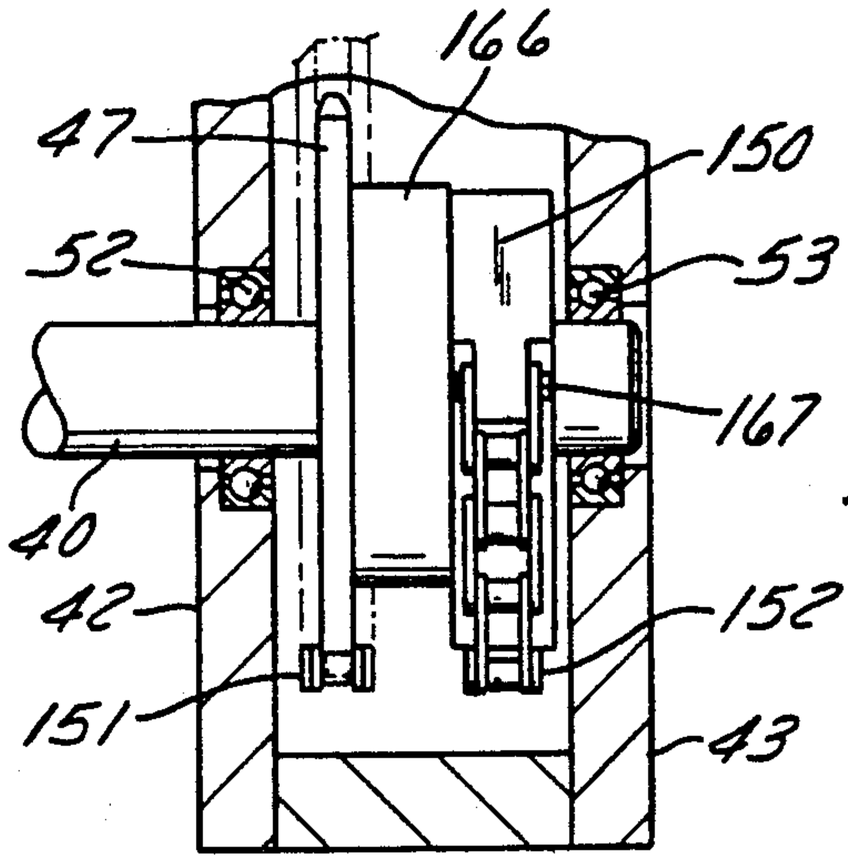
FIG. 9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43

FIG. 10

OPPOSED ARM WEB ACCUMULATOR

This is a file wrapper divisional of copending application Ser. No. 07/690,493, filed Apr. 25, 1991, now abandoned.

BACKGROUND OF THE INVENTION

The invention disclosed herein pertains to an accumulator for accumulating a substantial length of a running web such that if the infeed to the accumulator is stopped or slowed for a short interval, the web in storage is paid out continuously to a web utilizing machine so the machine has a constant supply and need not be stopped or slowed during any part of the interval.

One common use of a web accumulator is where a web is fed from a primary supply reel and it is necessary to splice the leading end of the web from a standby supply reel to the trailing end of a web from the primary supply reel in a manner which will not cause interruption of the web supply to a web consuming or utilizing device. In some known accumulators there is a row of spaced apart rollers on one swingable arm cooperating with another row of rollers which may be stationary or swingable on another arm. When the one arm with a row of spaced apart rollers on it is swung away from stationary rollers or the row of rollers on the other arm and the web is looped around the two sets of rollers, a substantial length of web can be accumulated. During normal running of the web, the arms will be urged to their maximum separation from each other for accumulating and storing the maximum length of web. If the supply of web to the accumulator is stopped for a short interval, the tension due to drawing web from the outfeed end of the accumulator causes the sets of rollers to move toward each other while the length of web in storage is paid out. After the end of the interval during which web infeed to the accumulator is stopped, the two relatively movable sets of rollers separate again to accumulate and store another length of web.

There is another general type of accumulator which has a set of rollers mounted on a movable carriage which can run linearly toward or away from a set of corresponding stationary rollers. The web is looped back and forth between the rollers on the movable and stationary components so that web is accumulated as the movable carriage moves away from the stationary assembly.

In application of web accumulators where web tension is of concern, designers must face the problems associated with friction and inertia. The consequence of these two factors may be appreciated when it is realized that the web may be running at a very high rate of speed when suddenly, for some reason, such as when making a splice, the infeeding web is stopped or decelerated. This change in web motion will result in a reaction by the components of the accumulator. Most notable of these reactions is the motion imparted to the movable assembly of the accumulator, whether swinging arm or linear carriage. Minimizing the inertia and friction associated with this reaction will minimize tension transients, and is a prime advantage of the invention described herein.

Also notable is the change in speed of the individual rollers. While roller inertia can actually be of benefit during a sudden deceleration, it must also be overcome when the infeeding web is returned to the original running speed. The roller nearest the infeed may have

come to a complete stop, while each succeeding roller has slowed to some speed slightly higher than the roller preceding it. As the web at the infeed is accelerated it can only be drawn into the accumulator as fast as the rollers can resume their original speeds. Since the force to accelerate these rollers is provided only by the tension in the web, it can be seen that minimizing the number of rollers and their inertias can allow a given system to operate successfully at lower web tensions. In prior art machines, friction and inertia are significant factors which limit their usefulness at low tensions. Thus, there is an important need for a web accumulator which provides the benefits of low friction and minimized inertia, allowing it to handle the most delicate of webs at high speeds without breakage or loss of control.

SUMMARY OF THE INVENTION

In general terms, the new dual opposed arm web accumulator comprises a base on which are arranged first and second axle shafts with their axes in parallel spaced from each other along a common center line. An arm is fastened to each axle shaft for swinging in spaced apart parallel planes toward and away from each other. The arms generally present the perspective of being opposite sides of a parallelogram. Web is looped back and forth between the rollers on one arm and rollers on the other arm. Means are provided for applying a torsional force concurrently to the axle shafts which causes one of the arms to swing through an angle away from one side of the center line and the other arm to swing away through a corresponding angle from the other side of the center line until the arms attain a maximum permissible angle relative to the center line during normal running of the web. The arms also swing correspondingly toward each other as stored web in the accumulator is withdrawn from the accumulator.

One feature of the new accumulator is that the arms can swing past each other to provide an open space into which the web is threaded initially through the free space between the two sets of rollers on the arms but without the need to loop the web around the rollers. The arms are allowed to swing to opposite sides of each other again automatically to create loops which form the length of web being accumulated and stored.

Another important feature of the new accumulator is that the arms are tied together mechanically such that they are completely counterbalanced to negate the effects of gravitational forces.

Another important feature of the new accumulator is that, unlike many prior art accumulators, it contains no linear slide mechanisms, which are especially subject to misalignment, contamination, wear and the resulting friction.

Another important feature of the accumulator is that, in comparison with prior accumulators, it achieves a large amount of web storage for a given number of rollers and for the space it occupies.

How the foregoing features and other objectives of the invention are implemented will appear in the ensuing more detailed description of a preferred embodiment of the invention which will now be set forth in reference to the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational, mostly diagrammatic, view of a web handling machine in which the new accumulator may be installed;

FIG. 2 is a front elevational view of the accumulator with its roller carrying arms angulated to the position in which the maximum length of web is accumulated;

FIG. 3 is similar to FIG. 2 except that the arms of the accumulator would be moving towards each other as would be the case when infeed of web is stopped and the great length of web which is stored in the accumulator is being paid out;

FIG. 4 is a view taken on the line 4—4 in FIG. 5 of the mechanism for driving the arms apart in unison to effect accumulation of a length of web;

FIG. 5 is a side elevational view taken on the line 5—5 in FIG. 4, of the assembled accumulator with some parts being shown in section;

FIG. 6 shows the two arms of the accumulator swung past each other to provide a clear passageway for threading the web into the accumulator at the start of a web run;

FIG. 7 shows the position of the arms immediately after the web has been threaded into the accumulator and separation of the arms is underway to increase the length of the web which is to be held in storage;

FIG. 8 is a front elevational view of an alternate but preferred embodiment of the new accumulator;

FIG. 9 is similar to FIG. 8 except that the arms are swung to a position wherein a substantially minimum amount of web would be in storage; and

FIG. 10 is a view, partly in section, taken on a line corresponding with 10—10 in FIG. 9.

DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 1 illustrates an arrangement in which the new accumulator, generally designated by the numeral 10, can be used advantageously. In this figure, web 11 is being fed from a supply reel 12 from which the web runs to a splicer 13. The splicer may be any of a variety of conventional splicers which can join the leading end 14 of a web from a standby supply reel 15 to the trailing end of the web from the primary supply reel when the web is just about ready to run out from the primary supply reel. Reel drivers 16 and 17 are provided for rotating the primary and standby supply reels, respectively, for the purpose of feeding out the web to the accumulator downstream. Typical reel driver 16 comprises a belt 18 running on rollers 19 and 20. Roller 20 is fixed to a shaft 21 which is driven rotationally by a motor, not visible, which is behind the front plate 22 of the machine. The belt and rollers are carried on a frame 23 which has an arm 24 connected to the piston rod 25 of a pneumatic actuator 26. The actuator 26 is used to push the belt 18 into frictional driving relationship with the periphery of roll of web on the supply reel. This supply reel drive device 16 is a well known type. After the web passes through accumulator 10 it goes through a metering device 27 which is symbolically represented. From the metering device, the web is drawn in the direction of the arrow 28 into a web utilizing device, not shown, which could be a disposable diaper making machine.

Normally, the web 11 after leaving splicer 13, will continue over idler rollers 29 and 30 to the infeed roller 35 of the accumulator 10. And, after being looped back and forth in the accumulator to lengthen the amount of web in storage, the web continues from the outfeed roller 36 of accumulator 10.

When the web on primary supply reel 12 is depleted to the extent that its trailing end is about to unwind from the reel, drive 16 decelerates reel 12 so as to bring it to a stop, at which time the splicer 13 splices the leading end of the web on reel 15 to the expiring web. It is quite typical that conventional splicers would simultaneously sever the expiring web, leaving what is now a continuous web running from the reel 15 through to the web accumulator. After a short interval, during which said splicing action occurs, the run of web between splicer 13 and the infeed roller 35 is not moving, and is under essentially the same tension as it is in regular feeding of the web. Of course, at this time the great length of web which is formed within the several loops in the accumulator is being paid out of the accumulator from outfeed roller 36.

Attention is now invited to FIG. 2 wherein the parts of the accumulator are in the position in which they would be during storage of the maximum amount of web as is the case when the web is being drawn out of the accumulator and is being fed into the accumulator at the same rate. In other words, in this example, the swinging arms 37 and 38 are swung apart as far as is practical in FIG. 2 to store the maximum amount of web 11 in the form of loops running back and forth between the arms. Arms 37 and 38 are clamped to axle shafts 39 and 40, respectively, for rotating with the axle shafts. The axes of the axle shafts 39 and 40 lie on a center line which is marked 41 in FIG. 2. As will be explained shortly hereinafter, axle shafts 39 and 40 are driven apart in unison so that the arms always maintain the same angular separation from common center line 41. The arms 37 and 38 turn clockwise together and counterclockwise together.

Attention is now invited to FIGS. 2, 4 and 5 for a discussion of how the arms are driven apart to bring about the accumulation of web and how the arms swing toward each other to pay out accumulated web to the outfeed when infeed of web is stopped for a short interval. First refer to FIG. 4 which shows that the mechanism for operating the arms 37 and 38 is contained within a housing whose front wall 42 appears in FIG. 4 and whose rear wall 43 appears in FIG. 5. In the latter figure the end walls 44 and 45 of the housing are also visible. The housing is much like a box whose rear wall 43 is fastened to the front face plate 22 of the machine depicted in FIG. 1.

Considering FIGS. 4 and 5, primarily, one may see that the rotatable axle shafts 39 and 40 have tooth wheels in the form of sprockets 46 and 47 fastened to them. Sprocket 46 is bolted to a clamp 48 which provides for clamping the sprocket to axle shaft 39 by way of tightening a clamping screw 49. A key and keyway, not visible, may also engage the sprocket to the axle shaft. The other sprocket 47 is similarly bolted to a clamping member 50 which is provided with a screw 51 which can be tightened to clamp the sprocket to axle shaft 40. Axle shaft 40 is journaled in ball bearings 52 and 53 which are set in suitable counterbored holes in the front and rear walls 42 and 43, respectively, of the drive mechanism housing. The other axle shaft 39 is similarly journaled for rotation in ball bearings 54 and 55. Swinging arm 37 is clamped to axle shaft 39 by means of a clamping element 56 which is essentially a split ring that is engaged to the shaft by tightening a machine screw 57. Swinging arm 38 is similarly clamped to axle shaft 40 by means of a clamping member 58. The previously mentioned outfeed roller 36 is shown in FIG. 5 to be journaled for rotation on axle shaft 39 by means of two internal bearings 59 and 60.

The roller is secured against shifting axially by collars **61** and **62** which are clamped to axle shaft **39**. Tubular outfeed roller **36** is preferably composed of a strong lightweight material so the roller has low inertia and requires the least amount of torque to start and stop. Previously mentioned infeed roller **35**, as shown in FIG. **5**, is journaled for rotation on axle shaft **40** Roller **35** is prevented shifting axially on axle shaft **40** by means of axially spaced apart collars **64** and **65** which are clamped to axle shaft **40**. From inspection of FIGURE **5**, it will be evident that arms **37** and **38** swing in planes which are parallel to each other.

Referring further to FIG. **5**, arm **37** has mounted to it several rollers **70**, **71**, **72** and **73**. These rollers are freely rotatable on respective shafts **74**, **75**, **76** and **77**. Arm **38** has mounted to it an equal number of rollers **78–81**. These rollers are mounted for rotation on respective shafts **82**, **83**, **84** and **85**. Roller **78** is typical. It is also preferably composed of a lightweight rigid material for the sake of minimizing inertia. Roller **78** is journaled for rotation on shaft **82** by means of two ball bearings **86** and **87**. The outboard end of shaft **82** is provided with a c-ring **88** for retaining bearing **87** on the shaft. The other bearing **86** is pressed on the shaft and retained against axial movement by abutting a shoulder **9** on the shaft **82**. Typical roller shaft **82** is mounted to arm **38** by means of a machine screw **90**.

As will be explained in detail later, arms **37** and **38** are driven rotationally, in this illustrative embodiment, by means of two pneumatic actuators **96** and **97**, whose piston rods **98** and **104** are interconnected by two chains **115** and **118**. The chains engage the toothed wheels or sprockets **46** and **47** for rotating the axle shafts **39** and **40** and the arms **37** and **38** thereon to accumulate web in response to movement of the pistons **100** and **101**. When infeed of web to the accumulator stops, the continued draw on the web at the outfeed causes the arms to swing toward each other. Two pneumatic actuators **96** and **97** are illustrated but it should be understood that either actuator could be removed and replaced with a section of chain and the remaining actuator could be replaced by a single actuator of sufficiently larger piston area to produce the actuating force which is the sum of the forces of the two actuators.

In FIG. **2**, arms **37** and **38** are both rotated through an angle relative to imaginary center line **41** which provides for storing the maximum length of web **11** in the loops of web spanning between the arms. Arms **37** and **38** are swung by the greatest angular amount as in FIG. **2** when web **11** is being fed into infeed roll **35** and is being drawn out of the accumulator over outfeed roll **36**. In FIG. **7**, arms **37** and **38** are swung close to each other which is a condition that occurs when infeed of web **11** is stopped and the accumulator has paid out just about all of the web it is permitted to pay out over the outfeed roller **36** before infeed of web must continue The manner in which the arms **37** and **38** are induced to swing out as in FIG. **2** for storing the maximum amount and are allowed to yield toward each other as in FIG. **7** to give up the stored amount of web will now be discussed in more detail in reference to FIGS. **4** and **5**.

As previously mentioned in respect to FIG. **4**, a sprocket **47** is fastened to axle shaft **40** for the infeed roller **36** and another sprocket **46** is fastened to the outfeed roller axle shaft **39**. Two pneumatic actuators **96** and **97** are mounted to the wall **42** of the housing. Actuator **96** has a piston rod **98** which extends slidably and sealably through both ends of the cylinder of actuator **96**. The piston fixed to rod **98** is drawn in solid lines and is marked **100**. Under ordinary operating conditions, that is, when arms **37** and **38** are swung through the maximum angle relative to center line **41**, piston **100** will be shifted by air pressure to its phantom line position designated by the numeral **100'**. Actuator **97** is similar to actuator **96**. They drive and yield together and each contributes one-half of the force for swinging arms **37** and **38**. Thus, when the piston **100** in actuator **96** is in its solid line position, piston **101** in actuator **97** is positioned as shown in hidden lines. The volume **102** on one side of piston **100** is occupied by air under pressure under all operating conditions of the accumulator. The pressure tends to force piston **100** to the left to develop a force which is translated to web tension. Similarly, when the volume **103** on the left side of piston **101** in actuator **97** is subjected to the same air pressure, piston **101** is biased to the right in FIG. **4**. The piston rod **104** of actuator **97** also extends through both ends of the actuator cylinder **105**. Pressurized air is supplied to the pressurizing volumes **102** and **103** of the actuators through a supply line **106**. The pressurized air enters actuator **97** by way of inlet elbow **107** and pressurized air enters actuator **96** through an elbow **108**. There are filter devices **109** and **110** connected to the respective cylinders **99** and **105** to allow exhaust of air when the pistons shift from their home position as depicted in FIG. **4**. The filters also prevent air containing contaminants from being drawn into the actuator cylinders when the pistons retract to their home positions depicted in FIG. **4**. A flexible member in the form of a chain **115** has one of its end **116** connected to an end of piston rod **98** of actuator **96** and has its other end **117** connected to an end of piston rod **104** of actuator **97**. Chain **115** is engaged with sprocket **46** for driving axle shaft **39**. Another chain **118**, has one of its ends **119** fastened to piston rod **98** of actuator **96** and the other of its ends **120** fastened to the piston rod **104** of actuator **97**. It would be possible to use toothed pulleys in place of sprockets **46** and **47** and to use toothed timing belts in conjunction with the pulleys instead of using chains.

It will be evident that when air pressure is applied in volumes **102** and **103** of actuators **96** and **97**, respectively, pistons **100** and **101** will shift in opposite directions and the chains running on sprockets **46** and **47** will drive axle shafts **39** and **40** and the arms **37** and **38** thereon in unison. When pistons **100** and **101** are in the positions in which they are depicted in FIG. **4**, arms **37** and **38** are departed by the least angular amount from the center line which extends between the axes of axle shafts **39** and **40**. As the pistons begin to move, the arm **38** passes through a position represented by phantom lines and marked **38''** and the other arm **37** moves through an angular position represented by the phantom lines marked **37''**. When the arms are in the position represented by phantom lines **37''** and **38''** they are positioned approximately as depicted in FIG. **3**.

During normal operating conditions, that is, when the infeed of web to the accumulator corresponds with the outfeed of web, the arms **37** and **38** rotate to the position in which they are depicted in FIG. **2** wherein they store the maximum amount of web in the loops between the rollers **70–73** and **78–81** on the respective arms **37** and **38**. In typical applications, the web is fed into the accumulator at a speed regulated by the position of the arms. This will cause the infeed web speed to equal outfeed web speed when the arms are positioned for optimum web storage. This will place the arms approximately as

shown in FIG. 2, with the air cylinder piston 100 at position 100', as shown in FIG. 4. Under any condition of infeed and outfeed velocities, the force developed by the actuators 96 and 97 is translated to rotational forces in the arms and resultant tension in the web. If outfeed velocity exceeds infeed velocity, the differential in web travel will tend to move the arms a backwardly, compressing the air in the cylinders. Pressure regulating devices (not shown) limit the increase in pressure in the cylinders and therefore regulate the tension.

It should be noted that since the axle shafts 39 and 40 for the arms are driven together the arms always will counterbalance each other. It should also be noted that the shafts and the arms swing clockwise together as they are accumulating a length of web loops between them and that they rotate counterclockwise together when infeed of web is interrupted and outfeed continues as a result of web being drawn by whatever web consuming or utilizing device is being supplied with the web from the accumulator.

Observe in FIGS. 4 and 5 that there is another sprocket 125 fastened to axle shaft 39. A chain loop 126 runs over the sprocket for the purpose of driving another sprocket 127. Sprocket 127 is fastened to the shaft 128 of a potentiometer 129. The lead wires of the potentiometer not shown. The potentiometer is supported on a bracket 130 which is clamped to the front wall 42 of the drive mechanism housing by means of machine bolts, such as the one marked 131, which pass through slotted holes in the bracket to provide for shifting the potentiometer until the proper tension is obtained in chain 126.

The potentiometer produces an analog signal relating to the angular position of the arms. This analog signal is typically supplied to the infeed device's web speed controller, not shown. In the application depicted in FIG. 1, the motor being controlled is the previously mentioned motor coupled to the shaft 21 of the belt drive mechanism 16. If, during regular operation, draw of web at the outfeed of the accumulator 10 increases such as to cause an angular change in the arm position of the accumulator, for example, the controller will cause the motor which drives the belt drive 16 to run faster until normal arm position is restored.

A feature of the invention is the ease with which the web can be threaded through the accumulator to begin a web run without the need for zigzagging the web around the rollers on the arms 37 and 38. Attention is invited to FIG. 6. Here it will be noted that arms 37 and 38 are crossed over each other as compared with their angular positions in FIG. 2 and 3, for example. Cross-over can be effected by grasping the outboard end of arm 38, for example, and drawing it past arm 37. Because the arms swing through an angle relative to the imaginary center line which runs through the axes of shafts 39 and 40 and the rollers on each of the arms are offset from each other as they pass the center line, the rollers on one arm can pass through the space between rollers on the other arms. When the arms are crossed over and spaced apart as they are in FIG. 6, it will be evident that the web 11 can be arranged as indicated without the need for making as much as a semi-circular loop around any of the rollers. Cylinders 99 and 105 of actuators 96 and 97 can have the normal air pressure applied to them at the time one arm is swung past the other manually. On the other hand, the actuator cylinders 99 and 105 can be unpressurized before a web run starts so only a small manual force is needed to cause them to cross over. It will now be appreciated why, during normal operation, when the arms are not crossed over, a free space remains between the end of actuator cylinder 99 and the displaced piston 100'. When the arm 38 is urged into cross-over position as explained in reference to FIG. 6, piston 100' is compelled to over travel and almost abut the adjacent end of the actuator cylinder. This amount of travel is all that is necessary to turn the axle shafts 39 and 40 enough to cause the rollers on the two arms to pass each other. Of course, since the arms are mechanically interconnected by means of the chains when the arm, such as 38, swings through a small angle, the other arm 37 swings through a corresponding angle in the other direction relative to the center line and a small amount of movement of one arm provides a rather large gap between arms for threading the web through the accumulator when setting up for a run of the machine.

In FIG. 7, manually deflected arm 38 has been released and tension is being applied to the web which causes the arms to swing past each other again. The arms then slowly swing away from each other in response to the pressure that is applied to the pistons in the pneumatic actuators 96 and 97.

In the FIG. 1–7 embodiment of the invention, the actual tension induced in the web by the torsional force applied to the arms is a trigonometric function of the angular relationship between the various web strands and the arms. As the angle between web and arm is varied from the perpendicular, relatively constant web tension can be achieved, for example, by having a microprocessor based controller, not shown, vary the actuator pressure in dependence on the signal received from the potentiometer 129. An alternative embodiment of the accumulator depicted in FIGS. 8–10 overcomes the variable torque requirement by a purely mechanical rather than electrical method. In FIGS. 8–10 parts which are similar to parts identified in the previously discussed embodiment are given the same reference numerals

In this embodiment, a varying radius cam 150 is fastened to axle shaft 40 along with sprocket 47. A closed loop chain 151 wraps around sprocket 47 and also around sprocket 46 which is on the other axle shaft 49. It will be evident that when one sprocket is forced to turn the other will turn through the same angle and the arms 37 and 38 will swing through a corresponding angle relative to a line passing through the centers of axle shafts 39 and 40. A short piece of chain 152 is fastened at one end 153 to the cam and is fastened at the other of its end 154 to the end of a piston rod 155. Piston rod 155 extends from the cylinder 156 of a pneumatic actuator 157. Cylinder 156 can swivel on a bracket 170. The cylinder has an inlet 164 for pressurized air and a filter-muffler 165. The end 153 of the chain 152 attaches to the curved cam 150 at the place where the radius of the profile 158 of the cam is minimum. The radius of the cam increases continually from the point 153 to the end 159 of the cam where the radius of the cam is largest. The effective radius or moment of rotation arm is that point at which the chain becomes tangent to the cam profile 158. From this, it can be seen that a constant force applied by the pneumatic actuator can produce a torsional force in the arms which varies with angular position. The varying radii of the cam are selected to compensate for the varying force vector between the web and arm angles, resulting in an effectively constant web tension, regardless of arm position.

FIG. 9 illustrates this situation where the chain **152** is tangent to the profile **158** of the cam at a point marked **162**. The radius of the cam at this point is marked **160**. In FIG. **8** the radius extending from the center of shaft **40** to the point of tangency between the chain and the profile **158** of the cam is marked **163**. It will be evident that the radius **160** in FIG. **9** where the arms are close to each other is substantially greater than the radius **163** in FIG. **8** where the arms **37** and **38** are angulated farther apart in FIG. **8** than they are in FIG. **9**. Since the air pressure driving the piston in actuator cylinder **156** is held substantially constant, it will be evident that the tension force in the chain **152** multiplied by the torque radius **163** in FIG. **8** will result in a torque related to the constant tension in chain **152** multiplied by torque arm **160**.

The pressurized air is supplied to actuator cylinder **156** through a tube **164**. The cylinder is also provided with a combination muffler and filter **165** which prevents contaminated air being drawn into the cylinder **156** when the piston moves in opposition to the air pressure due to arms **37** and **38** being forced toward each other while web infeed is stopped for an interval.

FIG. **10** show how axle shaft **40** is journaled for rotation in ball bearings **52** and **53** which are set in walls **42** and **43** of the mechanism housing as is the case in the previously described embodiment. In FIG. **10**, however, cam **150** is fastened to shaft **40** and sprocket **47** is fastened to a member **166**. Chain **152** is pivotally connected to cam **150** with a pin **167** as is evident from inspection.

It should be understood that actuators which differ from the two pneumatic actuators **96** and **97** in the FIG. **4** embodiment and the single actuator **157** in the FIG. **9** embodiment can be employed to swing arms **37** and **38** apart and have the arms swing toward each other. For example, a version of the accumulator, not illustrated, has ben constructed and satisfactorily operated wherein a torsion spring, not shown, serves as the actuator. The torsion spring has one end fixed and its other end fastener to one of the axle shafts **39** or **40**. During regular web transport the preloaded torsion spring causes the arms **37** and **38** to swing away from opposite sides of the center line. When infeed of web to the accumulator is slowed or stopped and outfeed continues, web tension in the outfeed overcomes the torsional force of the spring so the arms swing toward each other and pay out stored web. Both arms are driven in unison by having a closed loop chain connecting sprockets on the axle shafts.

In another embodiment which is not illustrated, a commercially available torque motor is mechanically coupled to one of the axle shafts. The axle shafts are connected for being driven in unison by a closed loop chain. Using an appropriate commercially available programmable controller, the torque motor can be caused to vary its torque in accordance with its rotational angle.

Although two implementations of the concepts of the new accumulator have been described in detail, such description is intended to be illustrative rather than limiting, for the invention maybe variously modified and is to be limited only by interpretation of the claims which follow.

I claim:

1. A web accumulator comprising:

a base,

first and second axle arranged with their axes in parallelism and journaled for turning relative to said base, the axes of the axle shafts being spaced from each other along a common centerline,

first and second arms fastened to said axle shafts, respectively, for swinging in spaced apart parallel planes in response to turning of said axles shafts, said arms extending in generally opposite directions from the respective shaft axes,

first and second wheel means fastened to said first and second axle shafts, respectively,

a flexible member formed in a closed loop around both of said wheel means and engaged with said wheel means for turning said wheel means and the arms with said axle shafts concurrently through the same angle in response to translation of said flexible member resulting from one axle shaft being driven rotationally,

a torque arm fastened to one axle shaft and having a curved profile surface whose radius of curvature about the axis of said axle shaft varies over the length of the surface,

a force producing actuator,

a flexible element connected between said actuator and said curved surface for said flexible element to be maintained in tangential contact with said curved surface at points along said surface having radii of different lengths as said torque arm is rotated due to tension developed in said flexible element resulting from actuation of said actuator, rotation of said torque arm driving said one axle shaft rotationally to cause said one arm to swing through an angle away from one side of said centerline and the other arm to swing away through a corresponding angle from the other side of said centerline until the arms attain a predetermined maximum angle,

changes in the moment of force defined by the length of the radius at the point of tangency times the tension in the flexible element causing the torsional force on the axle shaft and first and second arms to vary in correspondence with the angle of the arms with respect to said centerline,

a web infeed roller rotatable on the first axle shaft and web outfeed roller rotatable on the second axle shaft,

a series of spaced apart additional rollers supported on each arm, the rollers on one arm extending from the plane in which the one arm swings toward the plane in which the other arm swings, the ends of the rollers opposite from the arm on which they are supported being free to provide for a web being looped around rollers on opposite arms in succession from said web infeed roller to said web outfeed roller such that the maximum length of web accumulated in said accumulator occurs when arms are swung to their said maximum angle.

2. The web accumulator according to claim **1** wherein said flexible member is a roller chain and said wheel means are sprockets.

3. The accumulator according to claim **1** wherein the actuator is operated with pressurized air.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,163,594
DATED : November 17, 1992
INVENTOR(S) : Thomas C. Meyer

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 10, claim 1, line 3, after "second axle" insert --shafts--.

Signed and Sealed this

First Day of February, 1994

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks